ELEMENTARY BIOLOGY

PLANT-ANIMAL-HUMAN

PEABODY AND HUNT

ELEMENTARY BIOLOGY

PLANT, ANIMAL, HUMAN

BY

JAMES EDWARD PEABODY, A.M.

HEAD OF THE DEPARTMENT OF BIOLOGY, MORRIS HIGH SCHOOL BRONX, NEW YORK CITY, AUTHOR OF "STUDIES IN PHYSIOLOGY" AND "LABORATORY EXERCISES IN ANATOMY AND PHYSIOLOGY"

AND

ARTHUR ELLSWORTH HUNT, PH.B.

HEAD OF THE DEPARTMENT OF BIOLOGY, MANUAL TRAINING HIGH SCHOOL, BROOKLYN, NEW YORK CITY

"The wild life of to-day is not wholly ours to dispose of as we please. It has been given to us *in trust*. We must account for it to those who come after us and audit our records." — HORNADAY.

New York

THE MACMILLAN COMPANY

1921

ELEMENTARY BIOLOGY

PLANT, ANIMAL, HUMAN

THE MACMILLAN COMPANY
NEW YORK • BOSTON • CHICAGO
DALLAS • SAN FRANCISCO

MACMILLAN & CO., LIMITED
LONDON • BOMBAY • CALCUTTA
MELBOURNE

THE MACMILLAN CO. OF CANADA, LTD.
TORONTO

TO

THE MEMORY OF

MARTHA FREEMAN GODDARD

WHOSE DEVOTED INSTRUCTION IN BIOLOGY IS A LASTING INFLUENCE FOR GOOD IN THE LIVES OF HUNDREDS OF BOYS AND GIRLS AND WHOSE RARE SKILL IN LEADERSHIP IS AN INSPIRATION TO EVERY TEACHER WHO KNEW HER

THIS BOOK IS DEDICATED

BY THE AUTHORS

PREFACE

ALL the activities of a plant, of an animal, or of man may be grouped in three classes. One class embraces the functions relating to the life of the individual organism. These functions have to do with the processes of eating, digesting, assimilating, taking in of oxygen, producing of energy, and excreting of waste matters. These may be called *the nutritive functions*, if the term is used in its broadest sense. To the second group of activities belong the functions that have to do with the perpetuation of the animal or plant species, and these are known as *the reproductive functions*. Living organisms, whether plant, animal, or human, may, in the third place, be considered in their relations to one another and especially to *the general welfare of mankind*. Thus we may discuss the beneficial or injurious effects, so far as man is concerned, of different kinds of insects or of various types of bacteria; we may learn of the activities of individual men or of groups of individuals which promote or retard the advance of human society; or we might, if we were to carry the study still farther, even seek to learn the ways by which the higher thoughts of mankind, as expressed in poetry, music, and religion, affect the development of the human race.

In the preparation of this text, the authors have sought to keep continually in mind these three classes of activities, and to unify the study of plant, animal, and human biology by choosing those topics for laboratory work or text description that have to do in a broad sense with one or the other of the three great groups of functions of living things to which

we have just referred. In doing this, they are conscious that many subjects have been slighted or altogether omitted which might well be treated in a year's work in either botany, or zoölogy, or human physiology.

Again, in the treatment of a given subject, for example, stems, fishes, or circulation, special emphasis might be laid on structure, on function, or on the relation of the given topic to human life. Books both interesting and scientifically worth while could be prepared along any one of these lines, or, if time permitted, all three phases might be equally emphasized. But when we remember that less than two hundred school periods will probably be devoted by the average student to the study of biology, the necessity for adhering pretty consistently to some one plan is obvious.

In the judgment of the authors the kind of biology most worth while for the average boy or girl of fourteen years of age is *not one based primarily on structure.* Young students are naturally more interested in activities or functions than they are in mere form or structure. Hence, if we wish to work with, rather than " against the grain," we must put function in the foreground of our discussion. Every boy and girl knows, too, that both plants and animals as well as human beings must have food and drink, and that they grow and reproduce their kind. It is relatively much easier, therefore, to unify a course like this along physiological lines than on the basis of morphology, or of homologies of structure, many of which are far too complicated to be made clear to young students.

If properly outlined and presented, there is probably no subject in the school curriculum that can be made of more service to a growing youth than can biology. Biological problems confront him at every turn, and if he is a normal being, he will have asked himself question after question

which an elementary knowledge of biology ought to help him to answer. Some of these questions may be the following: Whence comes the food and oxygen supply used by man? Why are food and oxygen needed in our bodies? Why are some substances beneficial to the body and others injurious? What is the cause of disease, and how is disease transmitted? And if we were to tabulate the biological questions that occur spontaneously to the average pupil in the first year in the high school, we should doubtless find that a great proportion of these questions had to do with the relation of the living world to human life. Is it not clear, therefore, if we are to outline a course in biology that will best fit the interests of the "live material," *i.e.* the boy or girl who is to take the course, that the central idea or factor must be man; that all the various functions considered must have some relation to human life; and that the course, to be of practical importance, must suggest to the youth better ways of carrying on his own life and of helping to improve the surroundings in which he lives?

In order, however, to treat intelligently such a function, for example, as respiration or digestion, it is of course necessary to know something of the machinery by which each of these processes is carried on, and so there must be at least a minimum consideration of the structure of plants, animals, and the human body. In every case, however, the authors have called attention only to those details which seem to be absolutely essential for an interpretation of the function under consideration. Whenever names in common use are sufficiently accurate for descriptions, these are chosen in preference to scientific terms. Frequently the latter are necessarily used, and so, whenever their meaning is made clearer by referring to their derivation from Latin or Greek, these derivations are indicated in parentheses.

The sections in coarse type contain the material that seems to the authors most essential for any clear understanding of the subject as a whole, while in fine type we have put additional laboratory work and text description which we believe to have an important bearing on the various topics discussed. If both coarse and fine print on animal, or plant, or human biology are used, sufficient material for a half-year course in either elementary botany, zoölogy, or human physiology will be provided.

In the judgment of the authors, plant biology should always be considered first and human biology last in the course for the following reasons: (1) Plants lend themselves far more readily to close observation and especially to experiments than do animals, and so fundamental processes which apply to all living things can be demonstrated scientifically from plant material. (2) Plants are the final source of all the food supply of animals and man, and if the composition and manufacture of the nutrients are taught early in the course, a solid foundation is laid for all subsequent study of nutrition in animals and man. (3) The purpose of the animal study is largely that of showing the adaptations of animal structure to functions and the relations of the animals studied to human welfare. (4) And finally, if human biology comes last in the course, it may be presented in such a way as to review, sum up, and give real significance to many of the facts learned earlier in the course. In fact, as the work proceeds, comparisons will constantly be made between plants, animals, and man to show that the essential differences in the three kinds of organisms consist not in the differences in the functions which they carry on, but in the organs by which the functions are performed.

So far as the order of individual topics under plant, animal, and human biology is concerned, the instructor should

plan the sequence that best fits the season. In fact, the last use that a good teacher will make of any laboratory manual or text-book is that of following it slavishly. It is the hope of the authors, however, that the laboratory guides and the text descriptions which follow may be sufficiently suggestive to help some teachers to work out improved methods in biological instruction. In Appendix II will be found a suggested order of topics which the authors have found satisfactory.

Living organisms are to a large extent to be regarded as chemical engines so constructed as to liberate different kinds of energy. No one, of course, knows in any ultimate sense how even the simplest functions are performed by the simplest animals or plants. But it is utterly useless to attempt to teach biological functions without first presenting some of the elementary principles involved in physical and chemical phenomena. For this reason the first chapter in Plant Biology is devoted to the study of the Composition of Lifeless and Living Things. In Chapter III is a brief discussion of the structure of a common plant, and since cells are fundamentally alike in structure and functions in all living organisms, emphasis is laid early in the course on the essential characteristics of these cellular elements in plants. Another topic which necessarily recurs throughout plant, animal, and human biology is the principle of osmosis and its applications. The authors have inserted experiments which in their experience have helped to fix in mind this important principle and which demonstrate the necessity of digestion in plants and animals.

After this brief consideration of the fundamentals of plant composition, structure, and processes, Chapters V, VI, and VII are devoted to the study of the adaptations of plants for performing nutritive and reproductive functions. In

Chapter VIII are grouped experiments and descriptions the aim of which is to show various ways in which plants are propagated. This treatment presents only the briefest statement of underlying principles, since any extended discussion of this topic belongs to a course in agriculture.

In Chapters IX (Plants in their Relation to Human Welfare) and X (Plant Classification) the method of presentation is strikingly different from that adopted in the rest of the book, particularly so in the treatment of the spore-bearing plants. The authors believe that every pupil should be taught something of these simpler forms (especially bacteria), and that he should get as many of these facts as possible by observation. But to expect much laboratory work from young students on difficult microscopic forms like many of these cryptogams, is, we are confident, quite out of the question. We have, therefore, frankly abandoned the inductive method of study and have suggested that the laboratory work be largely in the nature of demonstrations. It is, of course, understood that if these forms are studied, the drawings and descriptions will be prepared from material in the hands of the student.

In our judgment there are few if any biological topics which are more important in their practical bearings than is that of bacteria. As commonly studied the disease-producing effects of these organisms are emphasized so much that boys and girls do not appreciate that all the work of the higher plants depends ultimately upon the activity of these low forms of fungi. In order to bring out this aspect of the work of bacteria and for other obvious reasons the structure, physiology, and economic benefit of these organisms are considered in the chapter on the relation of plants to human welfare, while their pathogenic effects are reserved for discussion in human biology.

The method of presentation in "Animal Biology" is somewhat different from that employed in "Plant Biology," for the reason that several widely different types of animals are studied. Limitations of time compel a rigid and somewhat narrow selection of groups for intensive study, and only those functions of each animal are considered which have some relation to human biology, or which have a broad, economic bearing. Thus insects are discussed largely because of their injurious or beneficial effects upon mankind; birds and fishes, because of their economic importance, and because of the great need for their conservation; and one-celled animals because of the light they throw on cellular processes. Certain other somewhat less important topics are considered incidentally; for example, protective resemblance and metamorphosis among insects, and the striking adaptations of structure to function in the bills, feet, and feathers of birds.

The animals suggested for additional study, if time permits, are representative mammals, reptiles, amphibia, arthropods, molluscs, worms, and cœlenterates. In many classes there are students who can work faster than the others, or who are interested in pursuing further their biological studies. Such students may be directed in carrying on some of these studies either in class or outside of school hours. In any case, students are likely to acquire considerable information by reading these textbook descriptions and studying the illustrations.

All the work of the year should lead up to and culminate in human biology. Here, too, however, many important topics must be treated only superficially, or altogether omitted, on account of lack of time. The authors believe that in this, the most important part of the course, practical hygiene should be taught as effectively as possible, and that the necessity for good food, pure air, varied exercise, and suffi-

cient sleep should be continually emphasized. If boys and girls can be led to conform their daily habits to the principles of healthy living, the course in biology will have its highest justification.

In the treatment of Stimulants and Narcotics, the authors have tried to state in simple language the conclusions of experts regarding the effect of tobacco and alcohol, and to present the strongest scientific arguments against the use of these substances which are so injurious to growing youths.

No study of human biology should be allowed to leave in the mind of the student the idea that he is merely a chemical engine adapted only for the generation of a certain amount of physical energy. The primary object of all secondary education should be the development of character and efficiency, and the true teacher ought to find opportunity again and again to touch the individual life of the young student. Especially should this be true in the study of biology. Growing boys and girls ought to come to feel, as they have never felt, that they have in their keeping a most complex and wonderful piece of living machinery which can be easily put out of order or even wrecked. But, on the other hand, they should see that if the bodily machine is well cared for, it is capable of splendid work which may help to increase the sum total of human efficiency and happiness.

In the preparation of this book the authors have received a great many suggestions from the teachers in their own departments and those of other schools. Our thanks are due to Miss M. Helen Smith of the Manual Training High School, Brooklyn, N.Y., for several laboratory outlines which formed the basis of corresponding studies in the following pages. The authors have been especially fortunate in securing the constructive criticism of Dr. C. Stuart Gager, Director of the Brooklyn Botanic Garden of the Brooklyn Institute of

Arts and Sciences. He has carefully read all of the manuscript and the page proofs of the "Plant Biology."

We are indebted to Dr. H. J. Webber, Professor E. O. Fippin, and others at Cornell University, for valuable material and illustrations for the chapter on Plant Propagation. We wish, also, to express our hearty appreciation of the generous permission of Henry Holt & Co. to use some of the material published in Peabody's "Laboratory Exercises in Anatomy and Physiology." We are fortunate, too, in securing from the New York Botanical Garden photographs for the frontispiece, and for several fine cuts in the text, and from Professor E. M. East of Harvard University the cut for Fig. 52, "Plant Biology." Miss Mabelle Baker, Miss Clara Lang, Miss Margaret Cutler, and Miss Grace Gamble, students in our first-year classes, have kindly prepared for us the figures on which their several names appear.

We have been especially fortunate also in securing the assistance of experts who have read much of the manuscript of the "Animal and Human Biology" and many of the proof sheets. Dr. E. P. Felt, New York State Entomologist, Mr. E. R. Root, author of "A. B. C. of Bee Culture," and Professor Glenn W. Herrick of Cornell University, have given us valuable criticism of the chapter on Insects. Dr. W. T. Hornaday, Director of the New York Zoölogical Park, has read the chapters on Birds and Fishes. To Mr. J. M. Johnson, Head of Department of Biology of the Bushwick High School, we are also indebted for suggestions relating to Birds.

Much of the manuscript of the chapter on Foods received the careful criticism of the late Professor W. O. Atwater. Dr. William H. Park, Director of the Laboratories of the New York City Board of Health, and Dr. Thomas Spees Carrington, Secretary of the National Association for the Study and Prevention of Tuberculosis, have given invaluable

assistance in the preparation of the chapter on microörganisms. A considerable part of the "Human Biology" was critically read by Dr. F. C. Waite of the Western Reserve Medical School, by Mr. Harold E. Foster of the English Department of the Morris High School, and by the late Miss Martha F. Goddard of the Morris High School, to whose memory these volumes are dedicated.

To Mr. E. R. Sanborn of the New York Zoölogical Park, and to Mr. A. E. Rueff of the Brooklyn Museum, we are indebted for their skillful photography. The American Museum of Natural History, the Brooklyn Museum, the National Aubudon Society, Doubleday, Page & Co., Dodd, Mead & Co., Kny-Scheerer Co., Dr. C. F. Hodge of Clark University, Dr. H. A. Kelly of Johns Hopkins Medical School, Mr. C. W. Beebe of New York Zoölogical Park, and others, have permitted us to make use of illustrative material.

Cost prices for the items on the list of laboratory apparatus and equipment were kindly furnished us by Bausch & Lomb, Kny-Scheerer, and O. T. Louis; from these prices the estimates on pp. 173 to 177, Appendix I, were prepared.

J. E. P.
A. E. H.

December 31, 1912.

Set up and electrotyped. Published February 1913

Norwood Press
J. S. Cushing Co. — Berwick & Smith Co.
Norwood, Mass., U.S.A.

TABLE OF CONTENTS

PLANT BIOLOGY